

# PATENT SPECIFICATION

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## DRAWINGS ATTACHED

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## (54) APPARATUS FOR ELECTROLYTIC MACHINING

(71) We, GESELLSCHAFT FUER KERN-FORSCHUNG m.b.H., of 5 Weberstrasse, 75 Karlsruhe, Germany, a German body corporate, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention relates to an apparatus for producing internal grooves in a pipe, by electrolytic machining, in which the electrode and workpiece are moved relative to one another whilst maintaining a narrow gap therebetween, a liquid electrolyte being forced under pressure through the gap, and the working surface of the electrode along its entire length forming an angle of less than 90° with the direction of relative movement.

Electrolytic machining may be applied with advantage where normal mechanical machining methods encounter difficulties or cannot be used at all. The principle thereof, some examples and a number of fields of application are described in the periodical "Betriebs-Journal", year 1, (1967), volume 1, pages 3 to 5.

However, electrolytic machining speeds are relatively low, so that, for example, machining long narrow grooves, long machining times are required in comparison with mechanical methods.

The present invention has as object to provide a device for electrolytic machining which permits substantially higher feed speeds. It is more especially devised to form longitudinal grooves of small cross-section in the outer or inner surfaces of long, thin pipes. Such pipes are frequently required in nuclear physics as covers for nuclear fuels.

According to the invention there is provided apparatus for producing internal grooves in a pipe, by electrolytic machining, in which the electrode and workpiece are moved relative to one another whilst maintaining a gap therebetween, a liquid electrolyte being forced under pressure through the gap, wherein the working surface of the electrode along its entire length forms an angle of less than 90° with the direction of relative movement, and wherein the electrode

comprises a frusto-conical basic body of insulating material tapering in the direction of relative movement on the surface of which cathode material is applied in the form of a thin metal layer, the metal layer being interrupted by corresponding longitudinal recesses or grooves formed in the basic body, the width of the longitudinal recesses or grooves corresponding to the mutual clearance of the grooves to be electrolytically machined, and their depth corresponding to the inside diameter of said pipe.

To increase the accuracy of measurement of the electrolytically machined profile, the angle  $\alpha$  may increase in a direction opposite the direction of relative movement, either in stages or gradually.

The invention is based on the knowledge that the feed speed is limited not only by the maximum current density obtainable, but also by the region of the working surface of the

electrode at which the quotient  $\frac{F_A}{F_Q}$  is a minimum, where  $F_A$  signifies the working surface and  $F_Q$  the profile cross-section normal to the direction of feed.

The invention is particularly suitable for electrolytically machining grooves, since here this quotient may be maintained greater than along the entire working surface.

The cathode material may be deposited on the surface of the electrode by evaporation.

The width of the longitudinal recesses or grooves fixes the mutual clearance of the grooves to be electrolytically machined or the transverse profile and the angle and the length of the remaining metal-coated working surfaces of the electrode define the depth of the grooves formed.

An embodiment of the invention is described with reference to the drawings:

Fig. 1 shows schematically a device for producing internal ribs in a pipe.

Fig. 2 is a cross-section through the pipe on the line II-II of Fig. 1.

The pipe 1 to be machined is clamped in a chuck 2. The electrode 3 has a shaft 4 which is driven by a feed unit 5 in the direc-

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tion of the arrow A. The liquid electrolyte traverses the pipe 1 in the direction of arrow B and is forced through the gap 6 under pressure between the inside wall surface 7 of the pipe and the electrode 3. If a direct current is passed between the pipe 1 as anode and the electrode 3 as cathode this causes material to be eroded from the pipe 1 along the gap 6.

The working surface 8 of the electrode 3 forms an angle  $\alpha$  with the direction of feed (arrow A) of the electrode shaft 4 extending in the axial direction of the pipe 1, this angle increasing in a direction opposite the direction of feed, but remaining smaller than  $90^\circ$ . In the present case the electrode 3 consists of a frusto-conical basic body made of plastics material, on the end face and outer surfaces of which a thin metal layer has been applied which is in electrical connection with the shaft 4 via an inner centering pin 9. The metal layer is interrupted by grooves 10 formed therein, so that ribs are formed which support the remaining metal layer acting as working surface. The profile of these ribs determines the shape of the grooves 20 to be electrolytically machined (Figure 2).

If the ribs become narrower in the direction of feed, then recessed grooves are formed, the width of which increases in the direction of the pipe diameter. To produce helical grooves it is also possible to superpose a rotary movement on the feeding movement of the electrode. In this case the grooves 10 are machined in the cone, inclined relative to the pipe axis in accordance with the required pitch of the groove 20.

To obtain a perfect guidance of the electrode the shaft 4 or discs 11 mounted on the shaft may have the inside diameter of the bore of the pipe 1.

An electrode in accordance with the invention, having an aperture ratio of cone of

between 1 : 30 and 1 : 40 may reach feeding speeds higher than 100 mm/min. This ratio, with the predetermined depth of groove, is limited only by the pressure drop of the electrolyte and the volume of hydrogen forming therein. To keep the volume of the hydrogen gas small, it is therefore preferable to maintain the outflow side of the gap at super-atmospheric pressure.

#### WHAT WE CLAIM IS:—

1. Apparatus for producing internal grooves in a pipe, by electrolytic machining, in which the electrode and workpiece are moved relative to one another whilst maintaining a gap therebetween, a liquid electrolyte being forced under pressure through the gap, wherein the working surface of the electrode along its entire length forms an angle of less than  $90^\circ$  with the direction of relative movement, and wherein the electrode comprises a frusto-conical basic body of insulating material tapering in the direction of relative movement on the surface of which cathode material is applied in the form of a thin metal layer, the metal layer being interrupted by corresponding longitudinal recesses or grooves formed in the basic body, the width of the longitudinal recesses or grooves corresponding to the mutual clearance of the grooves to be electrolytically machined, and their depth corresponding to the inside diameter of said pipe.

2. Apparatus according to claim 1, wherein said angle increases in a direction opposite the direction of relative movement, either in stages or gradually.

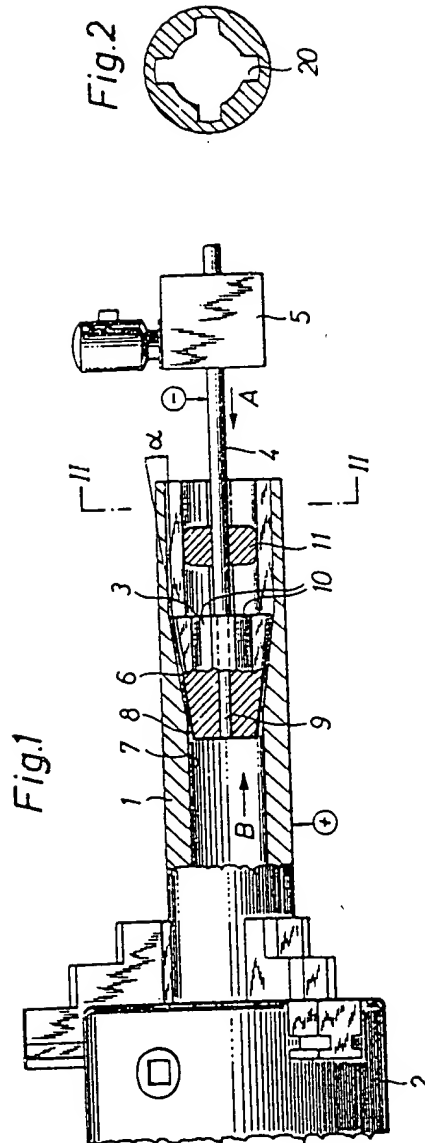
3. Apparatus for electrolytic machining substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

POTTS, KERR & Co.,

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